**3.** A magnetic component as claimed in claim 2 wherein the cobalt based layer is cobalt iron (CoFe).

**4.** A magnetic read head, which includes a spin valve sensor, comprising:

the spin valve sensor including:

a free layer structure that has a magnetic moment and an easy axis;

a ferromagnetic pinned layer structure that has a magnetic moment;

a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

a nonmagnetic conductive spacer layer located between the free layer structure and the pinned layer structure;

the free layer structure including at least one cobalt or cobalt based layer that has been formed by oblique ion beam sputtering in the presence of a field oriented in a direction of said easy axis.

**5.** A magnetic read head as claimed in claim 4 further comprising:

said at least one cobalt or cobalt based layer having been further formed by annealing after said oblique ion beam sputtering in the presence of said field oriented in said direction of the easy axis.

**6.** A magnetic read head as claimed in claim 5 wherein said annealing is at a temperature from 150°C to 270°C.

7. A magnetic read head as claimed in claim 4 further comprising:

the pinning layer structure including a nickel oxide (NiO) layer and an alpha iron oxide ($\alpha$ FeO) layer wherein at least one of the nickel oxide (NiO) layer and the alpha iron oxide ($\alpha$ FeO) layer has been obliquely ion beam sputtered.

**8.** .A magnetic read head as claimed in claim 7 wherein each of the nickel oxide (NiO) layer and the alpha iron oxide ($\alpha$ FeO) layer has been obliquely ion beam sputtered.

**9.** A magnetic read head as claimed in claim 4 further comprising:

the free layer structure including a nickel iron based layer that interfaces the cobalt or cobalt based layer; and

the cobalt or cobalt based layer interfacing the spacer layer.

**10.** A magnetic read head as claimed in claim 9 further comprising:

said at least one cobalt or cobalt based layer having been further formed by annealing after said oblique ion beam sputtering in the presence of said field oriented in said direction of the easy axis.

**11.** A magnetic read head as claimed in claim 10 wherein the cobalt based layer is cobalt iron (CoFe).

**12.** A magnetic read head as claimed in claim 11 wherein said annealing is at a temperature from 250°C to 270°C.

**13.** A magnetic read head, which includes a spin valve sensor, comprising:

the spin valve sensor including:

a free layer structure;

a ferromagnetic pinned layer structure that has a magnetic moment;

a pinning layer structure exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

a nonmagnetic conductive spacer layer located between the free layer structure and the pinned layer structure; and

the pinning layer structure including a nickel oxide (NiO) layer and an alpha iron oxide (α FeO) layer wherein at least one of the nickel oxide (NiO) layer and the alpha iron oxide (α FeO) layer has been obliquely ion beam sputtered.

**14.** A magnetic read head, which includes a spin valve sensor, comprising:

the spin valve sensor including:

a free layer structure that has a magnetic moment and an easy axis;

a ferromagnetic pinned layer structure that has a magnetic moment;

a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

a nonmagnetic conductive spacer layer located between the free layer structure and the pinned layer structure; and

the free layer structure including:

first and second cobalt or cobalt based layers and a nickel iron based layer with the first and second cobalt or cobalt based layers interfacing the spacer layer and a cap layer respectively and the nickel iron based layer being located between and interfacing the first and second cobalt or cobalt based layers; and

the cobalt or cobalt based layers and the nickel iron based layer having been formed by oblique ion beam sputtering in the presence of a field oriented in a direction of said easy axis.

**15.** A magnetic read head as claimed in claim 14 including:

nonmagnetic nonconductive first and second read gap layers;

the spin valve sensor being located between the first and second read gap layers;

ferromagnetic first and second shield layers; and

the first and second read gap layers being located between the first and second shield layers.

**16.** A magnetic read head as claimed in claim 15 wherein each of the cobalt or cobalt based layers and the nickel iron based layer is further formed by annealing after said oblique ion beam sputtering in the presence of said field oriented in said direction of the easy axis.

**17.** A magnetic read head as claimed in claim 16 wherein the pinned layer structure is an antiparallel (AP) pinned layer structure that includes:

ferromagnetic first and second antiparallel (AP) pinned layers with the first AP pinned layer interfacing the pinning layer and the second AP pinned layer interfacing the spacer layer; and

an antiparallel (AP) coupling layer located between and interfacing the first and second AP pinned layers.

**18.** A magnetic read head as claimed in claim 17 wherein the cobalt based layer is cobalt iron (CoFe).

**19.** A magnetic head assembly including a write head and a read head, the read head including a spin valve sensor, comprising:

the write head including:

ferromagnetic first and second pole piece layers that have a yoke portion located between a pole tip portion and a back gap portion;

a nonmagnetic write gap layer located between the pole tip portions of the first and second pole piece layers;

an insulation stack with at least one coil layer embedded therein located between the yoke portions of the first and second pole piece layers; and

the first and second pole piece layers being connected at their back gap portions; and

the read head including:

a spin valve sensor;

nonmagnetic nonconductive first and second read gap layers;

the spin valve sensor being located between the first and second read gap layers;

a ferromagnetic first shield layer; and

the first and second gap layers being located between the first shield layer and the first pole piece layer; and

the spin valve sensor including:

a free layer structure that has a magnetic moment and an easy axis;

a ferromagnetic pinned layer structure that has a magnetic moment;

a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

a nonmagnetic conductive spacer layer located between the free layer structure and the pinned layer structure; and

the free layer structure including:

first and second cobalt or cobalt based layers and a nickel iron based layer with the first and second cobalt or cobalt based layers interfacing the spacer layer and a cap layer respectively and the nickel iron based layer being located between and interfacing the first and second cobalt or cobalt based layers; and

the cobalt or cobalt based layers and the nickel iron based layer having been formed by oblique ion beam sputtering in the presence of a magnetic field oriented in a direction of said easy axis.

**20.** A magnetic head assembly as claimed in claim 19 including:

a ferromagnetic second shield layer;

a nonmagnetic isolation layer located between the second shield layer and the first pole piece layer.

**21.** A magnetic head assembly as claimed in claim 19 wherein each of the cobalt or cobalt based layers and the nickel iron based layer is further formed by annealing after said oblique ion beam sputtering in the presence of said field oriented in said direction of the easy axis.

**22.** A magnetic head assembly as claimed in claim 21 wherein the pinned layer structure is an antiparallel (AP) pinned layer structure that includes:

ferromagnetic first and second antiparallel (AP) pinned layers with the first AP pinned layer interfacing the pinning layer and the second AP pinned layer interfacing the spacer layer; and

an antiparallel (AP) coupling layer located between and interfacing the first and second AP pinned layers.

**23.** A magnetic head assembly as claimed in claim 22 wherein the cobalt based layer is cobalt iron (CoFe).

**24.** A magnetic disk drive including at least one magnetic head assembly that includes a write head and a read head, the read head including a spin valve sensor, comprising:

the write head including:

ferromagnetic first and second pole piece layers that have a yoke portion located between a pole tip portion and a back gap portion;

a nonmagnetic write gap layer located between the pole tip portions of the first and second pole piece layers;

an insulation stack with at least one coil layer embedded therein located between the yoke portions of the first and second pole piece layers; and

the first and second pole piece layers being connected at their back gap portions; and

the read head including:

a spin valve sensor;

nonmagnetic nonconductive first and second read gap layers;

the spin valve sensor being located between the first and second read gap layers;

a ferromagnetic first shield layer; and

the first and second read gap layers being located between the first shield layer and the first pole piece layer; and

the spin valve sensor including:

a free layer structure that has a magnetic moment and an easy axis;

a ferromagnetic pinned layer structure that has a magnetic moment;

a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

a nonmagnetic conductive spacer layer located between the free layer structure and the pinned layer structure; and

the free layer structure including:

first and second cobalt or cobalt based layers and a nickel iron based layer with the first and second cobalt or cobalt based layers interfacing the spacer layer and a gap layer respectively and the nickel iron based layer being located between and interfacing the first and second cobalt or cobalt based layers; and

the cobalt or cobalt based layers and the nickel iron based layer having been formed by oblique ion beam sputtering in the presence of a magnetic field oriented in a direction of said easy axis;

a housing;

a magnetic disk rotatably supported in the housing;

a support mounted in the housing for supporting the magnetic head assembly with said ABS facing the magnetic disk so that the magnetic head assembly is in a transducing relationship with the magnetic disk;

a spindle motor for rotating the magnetic disk;

an actuator positioning means connected to the support for moving the magnetic head to multiple positions with respect to said magnetic disk; and

a processor connected to the magnetic head, to the spindle motor and to the actuator for exchanging signals with the magnetic head, for controlling movement of the magnetic disk and for controlling the position of the magnetic head.

**25.** A magnetic disk drive as claimed in claim 24 including:

a ferromagnetic second shield layer;

a nonmagnetic isolation layer located between the second shield layer and the first pole piece layer.

**26.** A magnetic disk drive as claimed in claim 24 wherein each of the cobalt or cobalt based layers and the nickel iron based layer is further formed by annealing after said oblique ion beam sputtering in the presence of said field oriented in said direction of the easy axis.

**27.** A magnetic disk drive as claimed in claim 26 wherein the pinned layer structure is an antiparallel (AP) pinned layer structure that includes:

ferromagnetic first and second antiparallel (AP) pinned layers with the first AP pinned layer interfacing the pinning layer and the second AP pinned layer interfacing the spacer layer; and

an antiparallel (AP) coupling layer located between and interfacing the first and second AP pinned layers.

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**29.** A method of making a magnetic component ~~for an electrical~~ device comprising:

obliquely ion beam sputtering at least one cobalt or cobalt based layer with a magnetic moment and an easy axis in the presence of a magnetic field oriented in a direction of the easy axis; and

annealing said at least one cobalt or cobalt based layer after said ion beam sputtering.

**30.** A method as claimed in claim 29 wherein said cobalt based layer is formed of cobalt iron (CoFe).

32. A method of making a magnetic read head, which includes a spin valve sensor, comprising the steps of:

a making of the spin valve sensor comprising the steps of:

Sub D3

forming a free layer structure that has a magnetic moment and an easy axis;

forming a ferromagnetic pinned layer structure that has a magnetic moment;

forming a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

forming a nonmagnetic conductive spacer layer between the free layer structure and the pinned layer structure;

forming the free layer structure by obliquely ion beam sputtering at least one cobalt or cobalt based layer in the presence of a magnetic field oriented in a direction of said easy axis; and

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the oblique ion beam sputtering being at angles $\alpha = 40°$ and $\beta = 10° - 30°$, wherein angles $\alpha$ and $\beta$ are orthogonal.

33. A method of making a magnetic read head, which includes a spin valve sensor, comprising the steps of:

a making of the spin valve sensor comprising the steps of:

forming a free layer structure that has a magnetic moment and an easy axis;

forming a ferromagnetic pinned layer structure that has a magnetic moment;

forming a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

forming a nonmagnetic conductive spacer layer between the free layer structure and the pinned layer structure;

forming the free layer structure by obliquely ion beam sputtering at least one cobalt or cobalt based layer in the presence of a magnetic field oriented in a direction of said easy axis; and

after said oblique ion beam sputtering in the presence of said field oriented in said direction of the easy axis, further forming said at least one cobalt or cobalt based layer by annealing said at least one cobalt or cobalt based layer.

Sub C2

A12 Cont'd

**34.** A method of making a magnetic read head, which includes a spin valve sensor, comprising the steps of:

a making of the spin valve sensor comprising the steps of:

forming a free layer structure that has a magnetic moment and an easy axis;

forming a ferromagnetic pinned layer structure that has a magnetic moment;

forming a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

forming a nonmagnetic conductive spacer layer between the free layer structure and the pinned layer structure;

forming the free layer structure by obliquely ion beam sputtering at least one cobalt or cobalt based layer in the presence of a magnetic field oriented in a direction of said easy axis;

the pinning layer structure being formed by forming a nickel oxide (NiO) layer and an alpha iron oxide (α FeO) layer wherein each of the nickel oxide (NiO) layer and the alpha iron oxide (α FeO) layer has been formed by oblique ion beam sputtering.

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**36.** A method as claimed in claim 32 further comprising the steps of:

forming the free layer structure with a nickel iron based layer that interfaces the cobalt or cobalt based layer; and

said forming of the cobalt or cobalt based layer so that it interfaces the spacer layer.

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**37.** A method as claimed in claim 36 further comprising the step of:

after said oblique ion beam sputtering in the presence of said field oriented in said direction of the easy axis, further forming said at least one cobalt or cobalt based layer by annealing said at least one cobalt or cobalt based layer.

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**38.** A method as claimed in claim 36 wherein said cobalt based layer is formed of cobalt iron (CoFe).

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**39.** A method as claimed in claim 38 wherein said annealing is at a temperature from 150°C to 270°C.

**40.** A method of making a magnetic read head, which includes a spin valve sensor, comprising the steps of:

forming the spin valve sensor as follows:

forming a ferromagnetic pinned layer structure that has a magnetic moment;

forming a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

forming a nonmagnetic conductive spacer layer between the free layer structure and the pinned layer structure; and

forming the pinning layer structure of a nickel oxide (NiO) layer and an alpha iron oxide ($\alpha$FeO) layer wherein at least one of the nickel oxide (NiO) layer and the alpha iron oxide ($\alpha$FeO) layer has been obliquely ion beam sputtered.

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**41.** A method of making a magnetic read head, which includes a spin valve sensor, comprising:

a making of the spin valve sensor including the steps of:

forming a free layer structure that has a magnetic moment and an easy axis;

forming a ferromagnetic pinned layer structure that has a magnetic moment;

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forming a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

Sub C3

forming a nonmagnetic conductive spacer layer between the free layer structure and the pinned layer structure;

a making the free layer structure including the steps of:

obliquely ion beam sputtering first and second cobalt or cobalt based layers and a nickel iron based layer in the presence of a magnetic field oriented in a direction of said easy axis with the first and second cobalt or cobalt based layers interfacing the spacer layer and a cap layer respectively and the nickel iron based layer being located between and interfacing the first and second cobalt or cobalt based layers; and

after said oblique ion beam sputtering in the presence of said field oriented in said direction on the easy axis, annealing each of the cobalt or cobalt based layers and the nickel iron based layer.

**42.** A method as claimed in claim 41 including:

forming nonmagnetic nonconductive first and second read gap layers;

forming the spin valve sensor between the first and second read gap layers;

forming ferromagnetic first and second shield layers; and

forming the first and second read gap layers between the first and second shield layers.

Sub F1

**44.** A method as claimed in claim 42 wherein a forming of the pinned layer structure comprises the steps of:

forming ferromagnetic first and second antiparallel (AP) pinned layers with the first AP layer interfacing the pinning layer; and

forming an antiparallel (AP) coupling layer between the first and second AP layers.

**45.** A method as claimed in claim 44 wherein the oblique ion beam sputtering is at angles $\alpha = 40°$ and $\beta = 10° - 30°$ wherein angles $\alpha$ and $\beta$ are orthogonal.

**46.** A method as claimed in claim 44 wherein the step of oblique ion beam sputtering includes the steps of:

providing a sputtering chamber;

providing a nonmagnetic conductive target in the sputtering chamber that has a nominal planar surface;

positioning a substrate in the chamber that has a nominal planar surface at an angle to the nominal planar surface of the target;

providing an ion beam gun in the chamber for bombarding the target with ions which causes ions of the material to be sputtered from the target and deposited on the substrate to form said cobalt or cobalt based layers.

47. A method as claimed in claim 46 wherein the sputtering angles $\alpha = 40°$ and $\beta = 10° - 30°$ wherein angles $\alpha$ and $\beta$ are orthogonal and are angles between the nominal surface planes of the target and the substrate.

**48.** A method of making magnetic head assembly that includes a write head and a read head, comprising the steps of:

a making of the write head including:

forming ferromagnetic first and second pole piece layers in pole tip, yoke and back gap regions wherein the yoke region is located between the pole tip and back gap regions;

forming a nonmagnetic nonconductive write gap layer between the first and second pole piece layers in the pole tip region;

Sub C5

forming an insulation stack with at least one coil layer embedded therein between the first and second pole piece layers in the yoke region; and

connecting the first and pole piece layers at said back gap region; and

making the read head as follows:

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forming a spin valve sensor and first and second nonmagnetic first and second read gap layers with the spin valve sensor located between the first and second read gap layers;

forming a ferromagnetic first shield layer; and

forming the first and second read gap layers between the first shield layer and the first pole piece layer; and

a making of the spin valve sensor comprising the steps of:

forming a free layer structure that has a magnetic moment and an easy axis;

forming a ferromagnetic pinned layer structure that has a magnetic moment;

forming a pinning layer exchange coupled to the pinned layer structure for pinning the magnetic moment of the pinned layer structure;

forming a nonmagnetic conductive spacer layer between the free layer structure and the pinned layer structure;

a making of the free layer structure including the step of:

obliquely ion beam sputtering first and second cobalt or cobalt based layers and a nickel iron based layer in the presence of a magnetic field oriented in a direction of said easy axis with the first and second cobalt or cobalt based layers interfacing the spacer layer structure and a gap layer respectively and the nickel iron based layer being located between and interfacing the first and second cobalt or cobalt based layers; and

~~A7~~ contd Sub C5

after said oblique ion beam sputtering in the presence of said field oriented in said direction of the easy axis, annealing each of the cobalt or cobalt based layers and the nickel iron based layer.

**49.** A method as described in claim 48 including:

forming a ferromagnetic second shield layer;

forming a nonmagnetic isolation layer between the second shield layer and the first pole piece layer.

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**51.** A method as claimed in claim 49 wherein a forming of the pinned layer structure comprises the steps of:

forming ferromagnetic first and second antiparallel (AP) pinned layers with the first AP pinned layer interfacing the pinning layer; and

forming an antiparallel (AP) coupling layer located between the first and second AP layers.

**52.** A method as claimed in claim 51 wherein the oblique ion beam sputtering is at angles $\alpha = 40°$ and $\beta = 10° - 30°$ wherein angles $\alpha$ and $\beta$ are orthogonal.

**53.** A method as claimed in claim 51 wherein the step of oblique ion beam sputtering includes the steps of:

providing a sputtering chamber;

providing a nonmagnetic conductive target in the sputtering chamber that has a nominal planar surface;

positioning a substrate in the chamber that has a nominal planar surface at an angle to the nominal planar surface of the target;

providing an ion beam gun in the chamber for bombarding the target with ions which causes ions of the material to be sputtered from the target and deposited on the substrate to form said cobalt or cobalt based layers.

**55.** A method of making a magnetic layer and/or an antiferromagnetic (AFM) layer for an electrical device comprising the steps of:

obliquely ion beam sputtering at least one material layer from a target onto a substrate to form said magnetic layer and/or antiferromagnetic (AFM) layer;

the oblique ion beam sputtering being at angles $\alpha$ and $\beta$ wherein each angle $\alpha$ and $\beta$ is acute and wherein the angles $\alpha$ and $\beta$ are orthogonal with respect to each other.

**56.** A method as claimed in claim 55 wherein the angle $\beta$ is 10° to 30°.

**57.** A method as claimed in claim 55 wherein the angle $\beta$ is 20° and the angle $\alpha$ is 40°.

**58.** A method as claimed in claim 55 wherein the angle $\beta$ is 30° and the angle $\alpha$ is 40°.

**59.** A method as claimed in claim 55 wherein said at least one material layer is a nickel iron film and first and second cobalt based films with the nickel iron layer being located between the first and second cobalt based films for forming said magnetic layer.

**60.** A method as claimed in claim 59 wherein a second material layer comprising a nickel oxide film and an $\alpha$ phase iron oxide film that interface one another are obliquely ion beam sputtered at said angles $\alpha$ and $\beta$ for forming said antiferromagnetic layer.

**61.** A method as claimed in claim 60 wherein for each of said magnetic and AFM layers the angle $\beta$ is 10° to 30°.

**62.** A method as claimed in claim 61 wherein for said magnetic layer the angle $\beta$ is 20° and the angle $\alpha$ is 40°.

**63.** A method as claimed in claim 55 wherein the electrical device is a magnetic head assembly and further comprises the steps of:

said at least one magnetic layer being a ferromagnetic free layer;

a ferromagnetic pinned layer;

a nonmagnetic spacer layer located between the free and pinned layers; and

the pinned and spacer layers being ion beam sputtered at an angle $\alpha$ which is acute and at an angle $\beta$ which is zero.

**64.** A method as claimed in claim 63 wherein for the free layer the angle $\beta$ is 10° to 30°.

**65.** A method as claimed in claim 64 wherein the free layer has a magnetic moment with an easy axis and the oblique sputtering of the free layer is done in the presence of a magnetic field oriented parallel to said easy axis.

**66.** A method as claimed in claim 65 wherein after oblique sputtering the free layer the free layer is annealed at a temperature from 150°C to 270°C in the presence of said field oriented parallel to said easy axis.

**67.** A method as claimed in claim 66 wherein for the free layer the angle $\beta$ is 20° and the angle $\alpha$ is 40°.

**68.** A method as claimed in claim 67 wherein for the pinned and spacer layers angle $\alpha$ is 40° and angle $\beta$ is 0°.

**69.** A method as claimed in claim 68 further including the steps of:

forming said antiferromagnetic (AFM) layer interfacing the pinned layer wherein the AFM layer includes a nickel oxide film and an $\alpha$ phase iron oxide film that interface one another; and

ion beam sputtering the nickel oxide film and the $\alpha$ phase iron oxide film at angles $\alpha$ and $\beta$ wherein each angle $\alpha$ and $\beta$ are acute and wherein the angles $\alpha$ and $\beta$ are orthogonal with respect to one another.

**70.** A method as claimed in claim 69 wherein for the AFM layer the angle $\alpha$ is 40° and angle $\beta$ is 10° - 30°.